PROJECT ELECTRIC TOOTHBRUSH FINAL REPORT

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Team 007

Self-sustainable toothbrush

Our design team was presented with the challenge of taking an electric toothbrush and redesigning it to be as economically sufficient as possible to appeal to the economically conscious and the green population. We are going to achieve this by making the electric toothbrush self-sustainable. Before we did anything we needed to find out how the toothbrush worked and how much energy it was using so that we know how much energy we need to store so that the toothbrush can run on stored energy.

Throughout the report our design team has put together, there is information on what our customers want from the toothbrush and how we plan to give it to them. We have done some research on past patents on electric toothbrushes to see what other companies did, and we are taking them into consideration. Also in the report there is information on the two labs that our design team completed to find out how to make this electric toothbrush better. The most important thing we found out from the two labs is is how much energy that we need to store inside of a rechargeable battery so that the electric toothbrush can run for a decent enough amount of time for someone to be able to brush their teeth.

1.0 Introduction

The issues that our group is focused on are making the product self- sustainable while keeping the quality of cleaning and affordability of a normal electric toothbrush. To start our group brainstormed on how we can make our electric toothbrush self-sustainable. The ideas that arose were to put a crank on the toothbrush to crank it like someone would a crank flashlight, put a solar panel on the charging station to the electric toothbrush so that the energy absorbed from the sun then powers the toothbrush, and to put a small windmill outside of a window near the charging station so that wind energy can be converted into the energy used to power the electric toothbrush.

The team completed two labs and over the course of those two labs we each completed different jobs. Over the course of the two labs we found the mass of all of the parts of the electric toothbrush, the voltage of each of the batteries, how much power the toothbrush uses normally and while under work, and we dissected the toothbrush so that we could look at all of the parts and find out what made the electric toothbrush work. The tools that we used to complete all of our work so far include a scale, voltmeter, power supply, razorblade, saw, vise grip, needle nose pliers, and a decibel reader.

This progress report is composed of several different sections that cover all of the work that the design team has completed. Section two describes the manner in which the customer needs were gathered. Section three shows the design team's revised problem statement which was found by using the initial problem statement and combining it with the knowledge gathered about the customer needs. Section four shows the design team's report on all of the external searching completed which includes lab one, lab two, and information on the patent. Section five shows the design team's concept generation which includes sketches of how the electric toothbrush could be converted to become self-sustainable, it also shows which concept the design team chose as the way they are going to make the electric toothbrush self-sustainable. Section six shows what the design team came up with for the final design of the toothbrush. Section seven is the last section and it is composed of the final thoughts of the design team and the references that were used during the design process.

1.1 Initial Problem Statement

The initial problem was to find out how to make the electric toothbrush appeal more to the environmentally conscious/green population. As the design team working on the solution to the problem, we are redesigning this toothbrush to make it self-sustainable.

2.0 Customer Needs Assessment

1. This AHP pairwise comparison chart shows that the consumers are primarily concerned with environmental stability, and the quality of the toothbrush. However it still shows in what order of importance features like appearance and durability based on the weighted average.

	Retail Cost	Accessories	Quality of Clean	Easy to use	Environmental Stability	Durability	Apperance	Toothbrush Head	Size of toohbrush	Total	Weighted
Retail Cost	1	3	0.33	1	1	1	1	0.33	1	9.66	0.069172932
Accessories	0.33	1	0.17	3	0.17	1	1	1	1	7.67	0.054923022
Quality of Clean	3	6	1	9	3	3	9	3	9	46	0.329394916
Easy to use	1	0.33	0.11	1	0.17	1	1	0.18	1	5.79	0.041460795
Environmental Stability	1	6	0.33	6	1	3	6	1	6	30.33	0.217185822
Durability	1	1	0.33	1	0.33	1	3	1	3	11.66	0.08349445
Apperance	1	1	0.11	1	0.17	0.33	1	0.33	1	5.94	0.042534909
Toothbrush Head	3	1	0.33	6	1	1	0.33	1	3	16.66	0.119298246
Size of toohbrush	1	1	0.11	1	0.17	0.33	1	0.33	1	5.94	0.048561151

2. In the hierarchal customer needs list obtained from focus group and individual interviews. From this chart we can tell exactly what the consumers want in their product. Using this chart we start to take ideas to create a design.

1) Cost

1.1) Retail Cost

1.2) Accessories included with package

2) Design features

2.1) Environmental Stability, safer for the environment

2.2) Durability, lasts longer then average toothbrush

2.3) Appearance, personalized

2.4) Toothbrush head design

2.5) Size of the toothbrush

3) Use

3.1) Quality of the clean provided

3.2) Easy to use effectively

3. Below is a hierarchal customer needs list with the weighted values. Using this chart I we can use the weighted value to determine how much the consumer cares about each feature, or design for the product. We can them decide which designs to focus on when building our product.

1) Cost

1.2) Retail Cost (0.0692)

1.2) Accessories included with package (0.0549)

2) Design features

2.1) Environmental Stability, safer for the environment (0.217)

2.2) Durability, lasts longer then average toothbrush (0.083)

2.3) Appearance, personalized (0.043)

2.4) Toothbrush head design (0.119)

2.5) Size of the toothbrush (0.049)

3) Use

3.1) Quality of the clean provided (0.329)

3.2) Easy to use effectively (0.048)

Survey Questions:

1. Would you pay more for a better quality of cleaning?
2. How long would you want your toothbrush to last?
3. On a scale of 1 to 10, how much does the appearance of your toothbrush matter to you?
4. Would you pay more for the toothbrush if it was environmentally friendly?
5. How much would you pay for an environmently friendly toothbrush?
6. Do you prefer your toothbrush to be lighter or heavier than the average toothbrush?
7. Does the place that you store your toothbrush have a window that lets in sunlight?
8. Would you be willing to attach a small windmill to your window?
9. Would you be willing to attach a small solar panel outside of the window?
10. Do you prefer hard or soft bristles?

DATA SHEET 2 cont.	Bill of Materials									
Product Manufacturer/Model Number: Oral-B/										
Date:										
Disassembly method:										
Subtract and Operate Procedure (SOP): Yes, No.							*Force (Energy) Flow Diagram: Yes, No.*			
Part#	Part Name	QTY	SOP Effect	Function	Mass (oz, g)	Material	Manuf. Process	Dimensions	Cost	Time to Complete Part Dissection
111	Toothbrush Body	1		Acts as a hold for the toothbrush	.8 oz	Plastic	Molding, coloring	Cylinder	$0.20	20 minutes
121	Detachable toothbrush cover	1		Protects tootbrush bristle from outside effects	0.096 oz	Plastic	Molding	Two cylinders	$0.05	1 minute
131	Detachable toothbrush head	1		Clean teeth, powered by motor	0.064 oz	Plastic, thick thread	Molding, sewing	Two cylinders	$0.07	2 minutes
141	DC motor	1		Absorb energy from the batteries	1.152oz	Metal	Wiring	Rectangular cube	40 cents	10 minutes
152	Batteries	2		Power the toothbrush	1.728	Alkaline acid	Wiring	Cylinder	$1	2 seconds
161	Battery motor connector	1		Transfer energy from battery to motor	0.64	Metal	Connector	V- shaped	5 cents	5 minutes
171	Motor cover	1		Keep motor dry	0.224	Plastic	Protect dc-motor	Rectangular cube	5 cents	11 minutes
181	Battery cap	1		Protect batteries	0.192	Plastic	Conductor	Open cylinder	6 cents	1 second
191	Water seal	1		Protect batteries from water	.016	Rubber	Sealant	Circle	1 cent	1 second
201	Spring	1		Transfer energy from connector to DC-MOTOR	0.032	METAL	Connector	Cylindrical coil	1 cent	4 minutes

3.0 Revised Problem Statement

Based on the15 surveys the most important thing for consumers is the quality of cleaning of the toothbrush. Every survey taken showed that people would indeed pay more money for a quality of cleaning. The appearance of the toothbrush doesn't matter that much and our aim is to have an environmentally friendly toothbrush. And we plan to make the toothbrush between the prices of $6 and $10. Most of the consumers prefer using a lighter toothbrush than a heavy one. We should also let the consumers have the opportunity to choose between hard bristles and soft, and these bristles should be replaceable so they won't have to buy a new toothbrush.

4.0 External Search

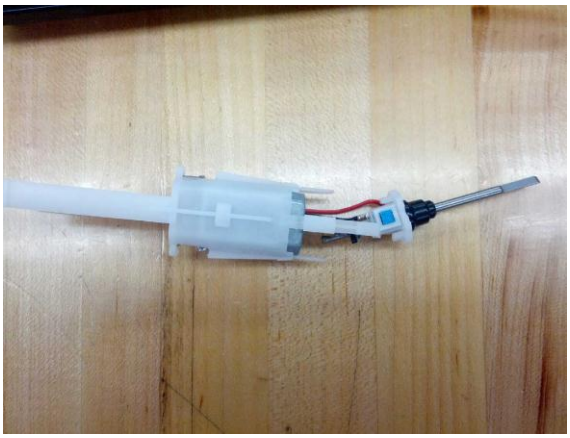
In this section we provide the information that we found from other sources and also the information such as patents that we had to search for. We also compared our toothbrush to other toothbrushes on the market through benchmarking and toothbrushes that used to be in the market through product archaeology.

4.1 Lab 1 & Lab 2 Reports

Lab 1:
We found how fast the brush head spun. We also found the power that the toothbrush would use during one use. From that, we found how long the toothbrush would last with those batteries in it. Following that, we disassembled our toothbrush. The parts were in their most basic form and we reported what we had in the Bill of Materials chart in section two.

Lab 2:
We tested the noise level of the toothbrush and calculate power of the batteries. From that, we found how long it could be used at the maximum output, the average output, and the minimum output. The outputs respond to the amount of power used to amount of pressure put down, which would increase in power output as pressure increased.

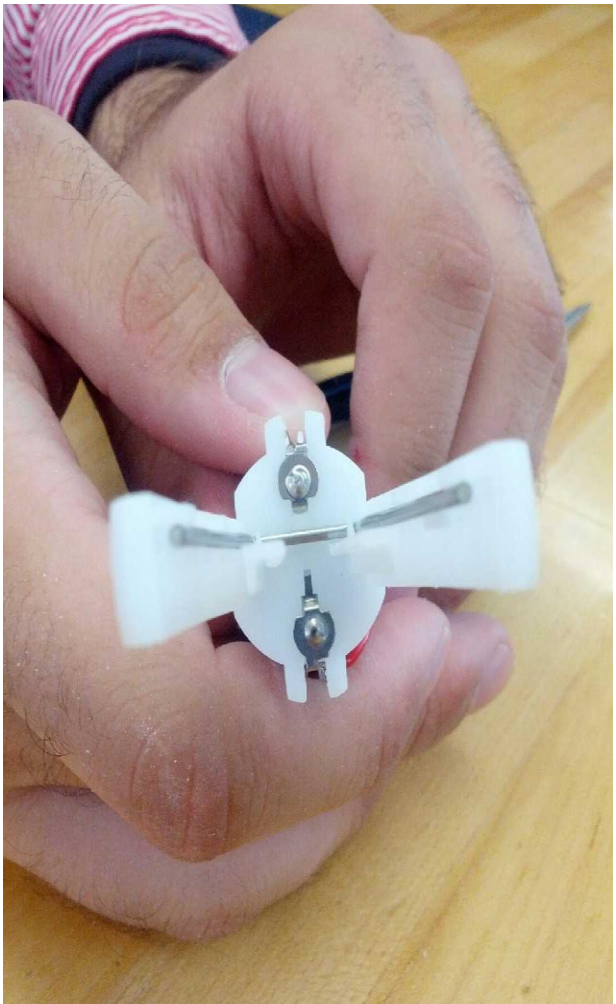
Visuals: Component pictures, sketches and/or solid models <u>(place team members name wh visual)</u>



This is the motor connection. It is where the batteries (would be on left) would put power into the motor (middle) which then would transfer the power into the spinning motion of the brush head (right).

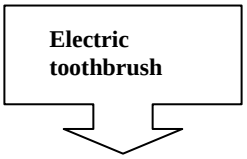
This is a closer look at the motor by itself, only being covered by the basic plastic protection.

This is a closer look at the battery connection.



This is the mechanism which used the motors power to spin the toothbrush.

Component, subassembly, assembly hierarchy:



Assembly Level

Plastic shell brush head battery connection

1) Battery cap
2 Water seal **1) Head cap,** **1) Batteries**
3) Plastic shell **2) Toothbrush head** **2) Motor connection**

Sub-assembly Level

DC-Motor
Spring
Motor cover

Battery motor connector

Component Level

Lab

4.2 Patent Search

Function	Art			
	Apparatus	Bristles	Structure	Bristle Head
Cleaning Interproximal Surfaces of Teeth	4882803			
Dual Row Cleaning		4894880		
Cleaning Hard to Reach Areas			5064212	
Curved To Fit Teeth		4847936		
Warped to Fit Obtuse Angle of Mouth				4800608

4.3 Product Archaeology

The toothbrush worked as most other electric toothbrushes, whereas with no force it performed at maximum and then with a force applied would lower the performance based on the force.
The basic manual toothbrush is still widely used. The manual toothbrushes have bristles that now are hard or soft, and now often have curved bristles to wrap around teeth. The first common day toothbrush had a flat line of bristles. The Oral-B advancepower 400 has a slight ridge around the end to curve better to teeth. A manual toothbrush you have to power down on your teeth for the most effective cleaning, which will most likely damage gums. The Advancepower 400 curves to the bottom of teeth and is gentle on gums for a cleaning just as effective. In this way, it provides the right amount of power to make the brushing experience better and easier.

4.4. Benchmarking

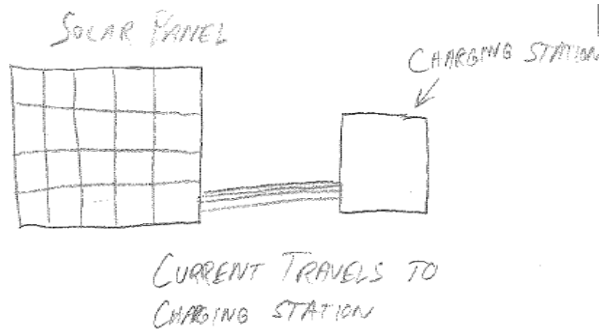
Tootbrush: Oral-B AdvancePower 400
Is a basic electric toothbrush
Newer Model: Oral-B Vitality Dual Power
Is an electric toothbrush
Has base stationary bristles for basic brushing
Has a recharging dock
Newer Model: Oral-B Professional Care SmartSeries 4000
Is an electric toothbrush
Is soft on teeth and gums
Has recharging dock
Has four different cleaning options
Can detect when you brush to hard and will slow and calm gums
Older Model: Oral-B Complete Scope Scented Toothbrush
Is a manual toothbrush
Includes tongue and cheek cleaner

Older Model: Oral-B Pro-Health Clinical Pro-Flex Toothbrush
Is a manual toothbrush
Acts softly on gums and enamel
Reduces gingivitis
Cleans hard-to-reach areas

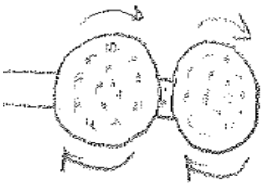
4.5 Design Target

The electric toothbrush is powered by batteries. Newer models are rechargeable. We will convert it to a rechargeable power. The bristles on the toothbrush are effective as all the newer models whereas the ridge on the edge provides a deep clean. The cost will stay low, but slightly more for the toothbrush because you save money by not having to buy batteries for it when they run out. The toothbrush appearance will be relatively like all other electric toothbrushes.

5.0 Concept Generation



This is the solar panel that we plan to put on the toothbrush charging station so that when the toothbrush is sitting on the charging station it is being charged by solar power.



This is the toothbrush head design that we plan to put on the toothbrush. We believe that the dual spinning heads will provide a better quality of clean as opposed to a single spinning head.

This is similar to the shape that we made our toothbrush. We made our toothbrush this shape because we believe that it is easier and more comfortable to hold.

6.0 Concept Selection

Below are some pugh charts that our team put together that led us to which concepts we chose as the final design for our sustainable electric toothbrush.

Toothbrush Head	Size	Cost	Weight	Power	Total	Rank
Weighting	0.2	0.2	0.3	0.3	1	
Concepts						
Dual-Oscillation	1	1	1	1	1	1
Oscillating head between two stationary sets	1	1	1	1	1	1
Tongue Cleaner	0	0	0	0	0	3
Dual-Oscillation	0	0	0	0	0	1
Oscillating head between two stationary sets	0	0	0	0	0	1
Tongue Cleaner	-1	-1	-1	-1	-1	3
Dual-Oscillation	0	0	0	0	0	1
Oscillating head between two stationary sets	0	0	0	0	0	1
Tongue Cleaner	-1	-1	-1	-1	-1	3

This is the toothbrush head pugh chart. In this chart it shows the thought process of our team as we chose what we wanted the toothbrush head to look like. From the concept generation sheets we created we found the best ideas and compared them to each other and against the different weights of the categories size, cost, weight, and power. The two ideas that tied for the best ideas were the Dual-Oscillation and the Oscillating head between two stationary sets.

Energy Mechanism for brush head	size	cost	weight	power	total	rank
Weight	0.2	0.2	0.3	0.3	1	
Concepts						
Spinning Toothbrush head	0	0	0	0	0	1
Moving Toothbrush head	-1	-1	-1	-1	-1	3
Vibration Toothbrush head	-1	-1	0	0	-0.4	2
Spinning Toothbrush head	1	1	1	1	1	1
Moving Toothbrush head	0	0	0	0	0	3
Vibration Toothbrush head	0	0	1	1	0.6	2
Spinning Toothbrush head	1	1	0	0	0.4	1
Moving Toothbrush head	0	0	-1	-1	-0.6	3
Vibration Toothbrush head	0	0	0	0	0	2

This is the Energy Mechanism for brush head pugh chart. This chart shows the best ideas out of all of the ideas that were generated within the team. The best idea that we found after comparing all three as to what their scores were when compared to size, cost, weight, and power was the spinning toothbrush head.

Human Factors	size	cost	weight	power	total	rank
weight	0.2	0.2	0.3	0.3	1	
concept						
Hand Grip	0	0	0	0	0	1
Adjustable Body	0	0	0	0	0	1
Collapsable Body	-1	-1	-1	-1	-1	3
Hand Grip	0	0	0	0	0	1
Adjustable Body	0	0	0	0	0	1
Collapsable Body	-1	-1	-1	-1	-1	3
Hand Grip	1	1	1	1	1	1
Adjustable Body	1	1	1	1	1	1
Collapsable Body	0	0	0	0	0	3

This is the Human Factors pugh chart. This chart shows the three best ideas of all of the ideas that our design team came up with. The two best ideas that were tied for first place after our comparing process was the hand grip and the adjustable body.

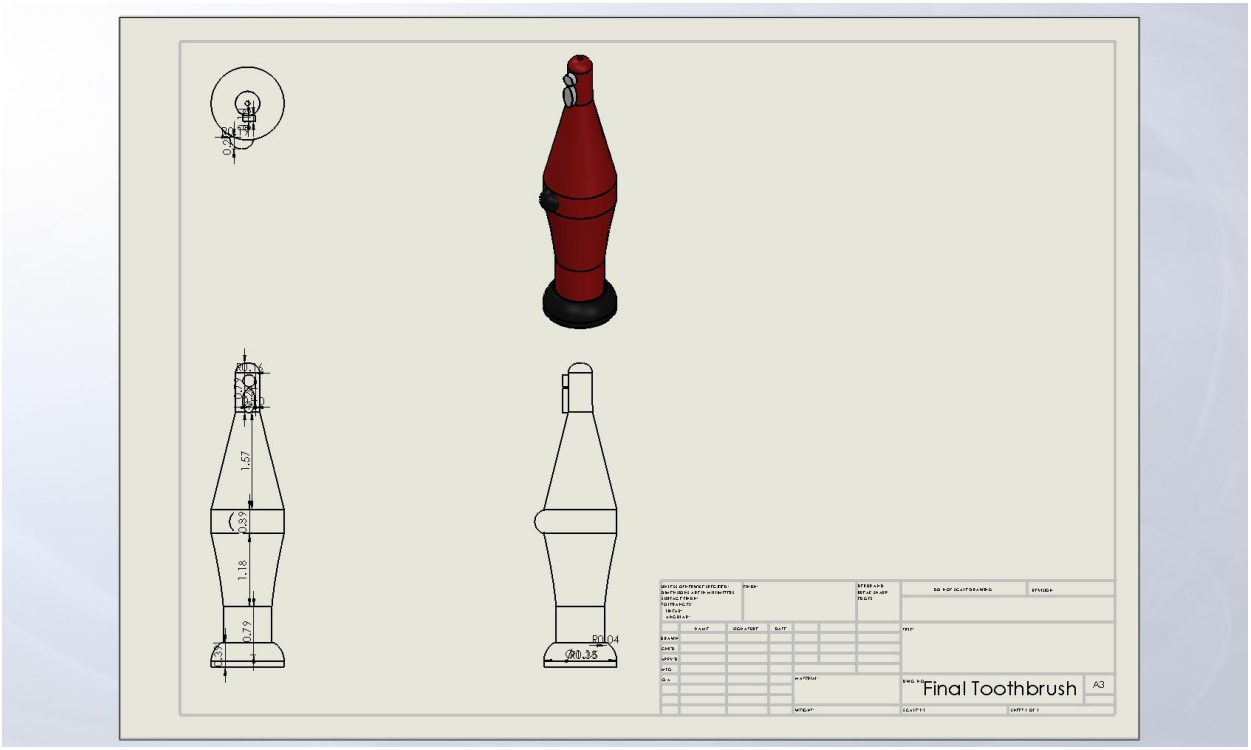
Power Generation	size	cost	weight	power	total	rank
weight	0.2	0.2	0.3	0.3	1	
concept						
Solar Panel power generation	0	0	0	0	0	1
Wind up power generation	0	0	0	-1	-0.3	2
magnetic power generation	-1	-1	-1	0	-0.7	4
Water power generation	-1	-1	0	0	-0.4	3
Solar Panel power generation	0	0	0	1	0.3	1
Wind up power generation	0	0	0	0	0	2
magnetic power generation	-1	-1	-1	1	-0.4	4
Water power generation	-1	-1	0	1	-0.1	3
Solar Panel power generation	1	1	1	0	0.7	1
Wind up power generation	1	1	1	-1	0.4	2
magnetic power generation	0	0	0	0	0	4
Water power generation	0	0	1	0	0.3	3
Solar Panel power generation	1	1	0	0	0.4	1
Wind up power generation	1	1	0	-1	0.1	2
magnetic power generation	0	0	-1	0	-0.3	4
Water power generation	0	0	0	0	0	3

This is the Power Generation pugh chart. This chart shows the four best ideas out of all of the ideas that our team came up with. The best idea after going through the comparing and ranking process was the solar panel power generation.

6.1 Final Design

Our design uses sustainable energy to power the toothbrush making it more environmentally friendly for our customers. It includes the charging station and of course the toothbrush. The toothbrush gets all of its energy from the solar panels attached to the base of the charging station. The energy from the charging station transfers into a battery located in the base of the toothbrush where batteries would normally be located.

6.2 Design Drawings, Parts List and Bill of Materials



Removable Parts List

Removable Part	Description
Tooth brush Charging Station	Uses solar energy to charge toothbrush
Tooth brush Body	Encases the internal structure of tooth brush
Tooth brush head	Cleans teeth

Bill of Materials

Part	Quantity	Cost	Function	Material
Solar Panel Strips	2	$6.00	Obtain Energy	Solar material
Motor	1	$1.00	Covert energy to use brush	----------
Tooth brush body	1	$1.00	Protect internal structure	Hard Plastic
Toothbrush Head	1	$0.50	Clean	Bristles and plastic
Gears & Screws	10	$0.50	Make design stable	Metal

6.3 How does it work?

The self-sustainable electric toothbrush runs strictly on solar power. It does this by having solar panels attached to the charging station that will sit in sunlight and absorb rays from the sun to charge the toothbrush, or absorb rays from the bathroom light to charge the toothbrush. After the toothbrush is charged it works just like any other electric toothbrush. Click the on/off switch and you are all set to start brushing.

7.0 Conclusions

Our design team has no doubt that this toothbrush could actually work. It is unlike any other toothbrush because it is completely self-sustainable using solar power and it still meets the wants of the customers. It has a great quality of clean and the grip is hand friendly while still being affordable.

References (Times New Roman, 16, Bold)

Note: That for the author-date system, references are listed in alphabetical order.

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